

# The Biology of the North American Crane-Flies (*Tipulidæ*, *Diptera*)

## I. THE GENUS *ERIOCERA* MACQUART

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### INTRODUCTION

The tribe *Hexatomini*, one of the ten sections into which the Tipulid flies have been divided, is widely distributed in the north temperate and torrid zones. The dominant genus is *Eriocera*, containing nearly one hundred described species, most of which are tropical forms. No species have been described from Europe or the Australian region but elsewhere the genus is represented by a host of forms, the number of species becoming less as one goes north or south from the equator. The males of many of the species have the antennæ exceedingly elongated, extending backward twice the length of the body. The wing-coloration in the northern forms is sober, undiversified, but in the tropics the wings of many species take on a banded or spotted appearance that is quite unparalleled in any other group of crane-flies.

The immature stages of this remarkable group of insects were quite unknown hitherto. Van Roser (Verzeich.-Wuerttemberg. Dipt., pt. 1, p. 262) states that the larvæ of *Hexatoma* (= *Anisomera* of authors) live in the sand along the banks of streams.

The members of this tribe of insects seem to be easily recognized in all stages. The adult flies, although closely resembling the *Limnophilini* in venation, have the minimum number of antennal segments for the family, there being but six of these segments in *Hexatoma* and not more than ten elsewhere in the

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\*Contribution from the Entomological Laboratory of Cornell University.

tribe. Other crane-flies have, as a rule, thirteen, fourteen or sixteen segments to the antennæ. The pupæ of the *Hexatomini* differ from all crane-fly pupæ known to the authors in the presence of six pairs of abdominal spiracles. The larvæ, in the powerful decussate mandibles, the great elongation of the maxillæ and the feeble chitinization of the mental region present striking differences from other crane-fly larvæ.

*Larval habitat*—The larvæ and pupæ of the three forms reared occurred together in a gravelly sand-bank along Fall Creek near Forest Home, Ithaca, N. Y. The soil in which the species occurred varied from a gravel of rather coarse texture to a fine clay thickly penetrated by grass-roots. Earlier in the spring, full grown larvæ of *E. spinosa* have been found in Fall Creek, Coy Glen and other rapid streams about Ithaca, at which time they occurred beneath stones far out in the bed of the creek. It seems probable that most of the larvæ live in sand near the water's edge; that many could live beneath stones in the creek seems impossible considering the closeness of search by members of the Limnological classes during the past few years.

On the morning of April 30, 1913, Mr. Lloyd found adults of *E. longicornis* very common on the island in Fall Creek above the second bridge in Forest Home. They were swarming in numbers around the flowers of Willow (*Salix*), that grows commonly on the flat shore. On the morning of May 1, Dr. Needham and Mr. Alexander went up to this island to observe the feeding habits of the species. Very few of the adult flies were to be seen on the wing but the insect was emerging by the hundred, and pupæ, cast pupal skins and teneral adults were very common. The pupæ of *longicornis* occurred an inch or two beneath the surface of the gravel, projecting from one-third to one-half of their length above the soil level, the caudal end attached. A few specimens pushed up about two-thirds of their lengths and remained perfectly quiet in the hot sun, settling lower and lower in their cavities until almost hidden; it seems probable that such specimens would not transform as strong, healthy individuals even if they emerged at all. Most

of the pupæ project about half their length from the soil and, attached by the caudal end, sway back and forth rather actively. In none was the beginning of transformation observed; specimens partly out of the skin were several times noted. The male has difficulty in extricating the very long antennæ from the pupal sheath. A field sketch made of the closely-allied *E. spinosa* is herein given and shows the relative position of the



Adult male of *Eriocera spinosa* O. S. emerging from the pupal skin. The coloring and hair-characters are from a fully colored adult.

parts of the body that are used: the first flagellar segment of the antennæ is directed straight away from the body, the fourth segment (second flagellar) at an acute angle to the third and thence the antennæ continue straight back to the sheath. The numerous spines on the underside of the flagellum of the males of *E. spinosa* and *longicornis* have long been known and the fact that they pointed away from the body noted; any use for this curious development has not been suggested. We observed the males in the act of withdrawing their antennæ and the method of procedure was about as follows: The tips of the fore femora are placed underneath the sharp spines on the flagellum and by raising the leg the antenna is pulled upward slightly. These spines are regularly arranged and since both forelegs work in unison, the spines function as cogs and the whole organ is gradually forced from its pupal sheath. The

whole body is carried very straight and stiff during this operation, the abdomen, especially, being very long and pale. The drawing out of the extreme tips of the antennæ is usually accomplished by the bending backward of the whole body of the insect, but this is not always the case. When the antennæ are freed, the insect then walks a few steps from the skin, first withdrawing its abdomen from the case. It then waits quietly until it attains more strength and color. It is probable that this teneral condition of the insect is its most dangerous period as it is defenseless against all enemies. An account of the enemies of the species is given in a later paragraph.

A count of one square foot of normal gravel was made at this time and showed the following: Twenty-eight living pupæ of *longicornis*, two larvæ of *spinosa*, one pupa of *Tipula bella* Lw., one large Tabanid larva; forty-seven cast pupal skins of *longicornis*, as well as most of the natural beetle associates given in a later place. This infestation was merely normal and many square rods of ground along the south bank of Fall Creek were in almost the same condition. One small larva, almost certainly of this species and described hereinafter as such, was found but practically all of the larvæ had passed into the pupal stage; many of these pupæ were very pale and feebly colored and evidently but newly transformed.

The emergence of the adults of *E. longicornis* from the pupæ took place during the late hours of the morning, most numerous between ten a. m. and noon.

Natural enemies of the pupæ and the teneral imagoes were found to be medium-sized black *Lycosid* spiders which were preying on the weak, uncolored adults in numbers; dozens of the spiders were noted with individuals of the crane-flies in their grasp; these spiders when alarmed would run away very rapidly but only in exceptional cases would they release their victims. A few *Attid* spiders were also noted with Erioceræ. A mound of gravel and sand containing many pupæ and skins was noted showing traces of a bird or mammal having preyed upon the pupæ.

Natural associates of *Eriocera* on these gravel beds were ground-beetles of the genera *Omophron*, *Schizogenius*, *Dyschirius*, *Bembidium* and *Agonoderus*; click beetles, *Cryptohypnus*, and rove-beetles, of which *Pederus*, *Lathrobium* and *Cryptobium* were the commonest forms. A large larva of *Corydalis* about ready to pupate and an abundance of larvæ and pupæ of horse-flies, *Tabanidæ*, were taken.

The larvæ of *E. spinosa* were found in great numbers in these gravel-banks on May 1. They occurred with young and mature pupæ of *E. longicornis* which were emerging in great numbers at this time. On May 27, both larvæ and pupæ of *spinosa* were found to be very abundant, larvæ being more numerous in the wetter places, pupæ in the dryer spots. They occurred at various distances from the water's edge, from within a foot to as far back as eight or ten feet from the shore. The pupæ occur in short, more or less vertical burrows, from one to three inches below the surface. Not often were larvæ and pupæ found in close proximity to one another. Pupæ of *spinosa*, as well as all others of the tribe so far as known, are very active when removed from their burrows, wriggling rapidly to and fro, and are exceedingly tenacious of life. Larvæ, as found on May 27, were mostly contracted; a few, however, were expanded and had the subterminal segment of the abdomen swollen. In this regard it may be mentioned that almost all of the larvæ of crane-flies that live in the sand or mud along stream banks, have this power of inflating the end of the abdomen. Larvæ of *Eriopterini*, *Limnophilini*, *Pedicini* and *Hexatomini* have been observed with this conspicuous enlargement. It is apparently used to propel the larva through the soil by alternate expansion and contraction of the segment.

Larvæ of this species were placed in breeding-jars on May 13, and adult flies emerged on the 28th. It is probable that the pupal stage is not longer than ten to twelve days, but this was undoubtedly accelerated by the increased warmth of the laboratory. The natural pupal period may be as long as two weeks. On May 30, a large number of larvæ and pupæ were brought into the laboratory in a bucket of gravel. Some of the

fully-grown pupæ transformed in the pail while being brought into the laboratory. The larvæ are almost certainly carnivorous, their powerful sickle-shaped mandibles inflicting a painful bite on tender parts of the hand.

The larvæ of *E. fultonensis* were found in the same situations on May 30. They occurred in company with numerous *spinosa* larvæ and pupæ, a few large Tabanid larvæ, a small Tabanid pupa, and the following beetle associates: *Bembidium*, *Schizogenius*, *Tachys*, *Cryptobium bicolor*, etc. These larvæ were placed in breeding-jars on May 30. One of these larvæ pupated on June 1 and emerged as an adult on June 6. This gives a very short indoor pupal period of a trifle less than a week.

The habits of the adult flies are still not well known. At 5:00 p. m. on May 1, 1913, the swarming of the species was observed near the place described above. At 5:40 p. m. they were flying in some numbers, swarms averaging from thirty to forty individuals being the most common. They kept out in the open, away from trees or bushes, and maintained an average height of from thirty to forty feet above the ground. Most of the swarms were out above the creek-bed but others were above the banks of the stream. The entire swarm seemed to face the gentle easterly breeze (i. e., up-stream). They swarmed about on a horizontal plane, the motions of each individual being mostly like a figure 8. The swarm covered considerable space, being from eight to ten feet high and about one-half of that distance through, the swarm scarcely moving from its position. Individuals constantly leave and rejoin the swarms. The insects sit on the tops of the willow bushes before joining the swarms and at this time are very wary. They dart up into the air and far overhead at the first approach of a possible enemy. It is very hard to catch specimens from the ground, but by standing on the bridge, which is only a little lower than the level of the swarm, it is rather easy to capture departing and incoming individuals. The next night, May 2, at 5:30 p. m., the insects were again swarming in numbers; at this time the swarms were smaller, of from twenty-five to thirty individuals, and they swarmed quite low, ten to fifteen feet up, just out

of reach of a net. The motion of individual specimens in a swarm varies at different times, now being a slow 8, now fast. One or two seemed to copulate in midair; this was done so rapidly, however, that it is not certain, the more so as it is so different from the mating habits of the closely-related *Hexatoma*.

The rearing of this material to the adult stage was accomplished by Mr. Lloyd; the biological notes herein given, the technical descriptions and the figures are by Mr. Alexander.

We wish to express our sincere thanks for the kind help and advice given to us by Dr. Needham during the progress of this study.

#### DESCRIPTION OF THE SPECIES

*Common characters of the larvæ*—The body is rather stout, yellowish, with a conspicuous bronzy sheen. The head-capsule (plate I, figure A) is long and narrow, and when retracted is completely concealed in the first thoracic segment, only the tips of the long apical maxillary lobe projecting. The mandibles are long, acutely pointed, decussate, provided with teeth on the inner basal half (a). One of the lobes of the maxillæ (c) is prolonged cephalad in a long, flat, blade-like appendage. The antennæ (b) are rather long, cylindrical. The framework of the head consists of a broad plate on either side in front, herein described as the genal plate (e), and two long bars of chitin extending backward on either side, one of these bars occupying a dorsal position, the other constituting the lateral margin of the capsule. The entire mental region seems to lack chitinized parts. The cauda (plate I, figures I-L) has the stigmal field free from lobes in *longicornis* or with four lobes in the other species.

*Common characters of the pupæ*—The head is provided with a group of lobes herein spoken of as the cephalic crest (plate II, figure A, a). Spines or tubercles occur in the different species on the scape of the antenna, the tentorium, the clypeus, the eye, the thoracic scutellum, etc. Pronotal breathing-horns short, cylindrical (*longicornis*), long, cylindrical (*fultonensis*)

or acute and curving ventrad at apex (*spinosa*). Segments II to VII of the abdomen with a spiracle on either side.

## KEY TO THE LARVÆ OF ERIOCERA

1. Head capsule long and narrow; lateral lobes of the fronto-labral sclerite not pronounced; labrum small. Caudal lobes not developed; hairs around the stigmal field very few (about twenty) but very long. (Genal plate produced into a lobe on the inner cephalic angle; a strong conical tooth on inner face of mandible at about midlength.)

*longicornis* Walk.

Head capsule broader; lateral lobes of the fronto-labral sclerite prominent; labrum well developed. Caudal lobes prominent, one pair being lateral and one pair ventral, bearing fringes of abundant long hairs. 2

2. Large larvæ (fully grown and extended, 40-45 mm. long, and 4-5 mm. in diameter); lateral lobes of fronto-labral sclerite not hairy; tubercles on labrum merely rounded; no strong, truncated tooth at mid-length of the mandible on the ventral face; hairs on caudal lobes prominent, reddish. Lateral lobe with a black line which is conspicuously enlarged at its inner end; ventral lobes with a black line which is forked, Y-shaped, at its inner end.

*spinosa* O. S.

Smaller, more slender larvæ (fully grown and extended, 18-26 mm. long, 2 mm. in diameter); lateral lobes of the fronto-labral sclerite clothed with abundant long hairs; tubercles on labrum cylindrical, truncated, chitinized; a strong, truncated tooth at mid-length of the mandible with a smaller one beside it; hairs on caudal lobes abundant but pale, indistinct. Lateral lobe with a black line which is not conspicuously enlarged at its inner end; ventral lobes with a black line which is enlarged at its inner end, not conspicuously forked.

*fultonensis* Alex.



## KEY TO THE PUPÆ OF ERIOCERA

1. Size large (length 25 mm. or over); pronotal breathing horns tapering to the acute tip; cephalic crest small, reduced to four tubercles; cell  $M_1$  on wing-pad present and usually evident; a strong spinous tubercle on either side of the median line at the base of the second abdominal tergite; a tubercle on the eye. (Mesonotal scutellar lobe, conspicuous, projecting). *spinosa* O. S.

Size small (length under 18 mm.); pronotal breathing horns about uniform in diameter throughout their length, blunt at apex; cephalic crest prominent, in some species so large as to conceal from beneath the pronotal breathing horns; cell  $M_1$  on wing-pad absent; no spinous tubercle at base of second abdominal tergite; no tubercle on eye.

2. Antennæ of  $\delta$  elongate, reaching almost to the tip of the wing-pad; lobes of the cephalic crest triangular, rather pointed at the apex, the lobes when viewed from beneath, tending to diverge apically; pronotal breathing horns short, not much longer than a single lobe of the crest; median scutellar lobe conspicuous, projecting; hind tarsi projecting considerably beyond the level of the inner two; wing-pads usually showing cross-vein  $r$  beyond the fork of  $R_2+3$ ; spine on antennal scape present.

*longicornis* Walk.

Antennæ of  $\delta$  short like the  $\varphi$ , reaching just beyond the base of the wing-pad; lobes of the cephalic crest more rounded, thickly covered with rounded protuberances, the lobes when viewed from beneath, tending to converge apically; pronotal breathing horns long, exceeding the whole crest in length; median scutellar lobe not apparent; all the tarsi about on a level; wing-pads pale, showing cross-vein  $r$  before the fork of  $R_2+3$ ; spine on antennal scape absent.

*fultonensis* Alex.

*ERIOCERA LONGICORNIS* Walker

1848 *Anisomera longicornis* Walker; List Dipt. Brit. Mus.;  
vol. I, p. 82.

## LARVA

Length, not fully extended, 13-13.5 mm.; diameter, 2 mm.; at subterminal swelling, 2.4 mm.

Color of larva light yellowish; almost uniformly cylindrical; the prothorax a little shorter than the other two thoracic segments; first abdominal segment simple, a little shorter than the metathorax; remaining abdominal segments with a faint basal constriction, dividing the segment into two annulets; remaining segments gradually increasing in length toward the end; the tenth segment is capable of being enormously distended; the last segment is narrowed, tapering to an obtuse point; this segment is clothed with numerous appressed hairs and two or three long, delicate hairs on the side of the segment.

*Head-capsule* long and narrow, measuring 1.5 by .275 mm. On the antero-dorsal portion of the head-capsule are the two genal plates (Snodgrass terminology), these rather broad, separated from one another along the dorsal median line by a wide space; the cephalic inner angles produced entad into prominent lobes (plate I, E), the caudal margin of the plates produced caudad in a fringe-like comb of chitinized points; these genal plates (which presumably include the vertex and genæ) are only about two-fifths the length of the head-capsule. Cephalad of the genal plates is a rounded median lobe (frons and clypeus) bearing at its apex a few small tubercles and a small quadrate projection (labrum); the lateral margins of this sclerite are gently rounded, not produced cephalad into prominent lobes. This plate consists of the fused frons, clypeus and labrum. Laterad of the genal plate is an elongate chitinized piece articulated with the base of the mandible on its dorso-lateral aspect, fused or closely applied to the genal plates for most of the length of the latter, thence articulated end-to-end with another elongated bar of chitin which extends caudad, expanding out at its tip and becoming approximated with its

fellow of the opposite side on the dorso-median line. This bar and the genal plates form the dorsal framework of the head-capsule. From the ventro-lateral angle of the mandible there arises another long bar of chitin which runs caudad ending about on a level with the median dorsal bar, very little expanded at its tip; this bar forms the lateral framework of the head-capsule. *Antennae* (plate I, C, b) arising on the inner cephalic angle of the genal plate just dorsad of the base of the mandible. It consists of a one-segmented, cylindrical, slightly curved organ which bears a number of long hairs at its apex, almost as long as the segment itself. *Mandibles* (plate I, H) exceedingly powerful, decussate, ending in a long, sharp point, on its caudal or inner face bearing a prominent conical tooth at about mid-length, and with other blunt protuberances nearer the base; one of the ventral strands of muscle has an egg-shaped, chitinized piece isolated in it. *Maxilla* arising just ventrad of the mandibular base, articulated on its outer caudal angle with the lateral chitinized bar of the head; the palpus is very short, lying underneath the base of the mandible, short-cylindrical, ending in a small cylindrical tip which is enclosed in a rounded fleshy apex; one of the two apical lobes of the maxilla (galea or lacinia) persists as a very elongate, pale, blade-like organ projecting far beyond the other mouth-parts, on the cephalic inner face with a long supporting strand of chitin which is forked near the base. *Mental region* entirely lacking strongly chitinized parts, the only indication of chitinization being a pale yellow area continued from the tips of the mandibles caudad but completely disappearing in caustic potash (1% solution, 24 hours).

*Stigmal field* small, oval, at the caudal end of the body, the stigmata occupying the dorsal portion of the area (plate I, K, L). Stigmata small, oval, placed rather obliquely, their dorsal ends directed inward, the distance between them less than the length of one or about equal to the small diameter of one. A faint dusky mark from the dorsal margin of each stigma to the edge of the field; a faint vertical stripe lying between the stigmata. There are no distinct lobes around the

stigmal field; at about midlength and lying on the lateral margin of the field is an elongate triangular black mark, its point directed outward; from this point and the margin of the field just above its tip, arise three long curved hairs directed outward. The ventral marks are larger, brownish black, these marks three-pointed at their dorsal end, the innermost of these points connected with its fellow of the opposite side; just laterad of this mark is a slender brown line which bears at regular intervals, three long, slender, curved hairs directed caudad; at the caudal margin of the large mark arise three very large hairs directed ventrad and arising from a common point so that they appear coalesced at their origin. Just laterad of these three bristles is still another delicate hair; so that surrounding the stigmal area there are about twenty of these long hairs. Caudal gills four, very short and inconspicuous, hidden underneath the subterminal enlargement.

Described from one larva taken in company with abundant pupæ of the same species, Forest Home, Ithaca, New York, May 1, 1913.

PUPA, ♂

*Antennal sheaths* enormously enlarged, viewed from beneath, the swollen bases nearly contiguous on the median line; just above and entad of the cephalic inner margin of the eye, provided with a sharp, chitinized spine placed in an eye-like depression. The antennæ bend laterad and dorsad to near the pronotal breathing horns and then ventrad, running caudad, closely appressed to the ventral side of the body, lying just inside the inner margin of the wing-sheath and outside the second pair of legs; the tip of the antenna is just beyond the middle of the fourth tarsal segment of the middle legs. In older pupæ the spines on the ventral side of the adult organ are clearly apparent through the cuticle. *Cephalic crest* (plate III, E)—From between the bases of the antennæ arises a flattened crest directed cephalad, deeply bifid by a square median notch, each of the lateral lobes thus formed being provided with chitinized points which are beset with sparse hairs; on each

side at the base of the crest, just cephalad of the swollen antennal base is a small subchitinized tubercle bearing a bristle. *Eyes* moderately large, occupying the space between the scape of the antennæ and the basal segments of the antennal flagellum. The anterior arms of the tentorium show through the cuticle, the arms rather short, elongate-triangular, directed toward the caudal end of the eye. *Labrum* large, roughly triangular, transversely wrinkled and bearing a conspicuous tubercle on either side near the base (which probably represents on the ectal surface the propharynx underneath, according to Dr. MacGillivray). The lobes of the *labium* project caudad on either side of the labrum, occupying the space just cephalad of the fore coxa and proximad of the tip of the fore femur. The *maxillæ* are represented by a quadrate plate on either side, lying just caudad of the eye, laterad of the clypeus and labium and cephalad of the knee-joint.

Thoracic notum quite convex, the *pronotal breathing horns* short, directed cephalad, dorsad and laterad, distinctly crenulated, not visible from beneath. The *mesonotal præscutum* delicately wrinkled medially, the V-shaped suture rather indistinct in young pupæ, clearer in darker, older pupæ. Median lobe of the mesonotal scutellum well indicated, projecting dorsad and caudad as a conspicuous point. *Wing-pad* attached opposite the basal quarter of the fore tibia, directed caudad, the tip of the pad lying opposite the ends of the second tarsal segments of the fore and middle legs and opposite the end of the second abdominal segment. *Halteres* originating on the side of the metanotum, hidden by the wing-pad, the tip at the extreme base of the second abdominal segment and just before the apex of the hind tibia. *Fore legs* (plate II, A), viewed from beneath the fore coxæ (*g*) are seen lying just caudad of the lobes of the labium; the coxa, trochanter and extreme base of the femur lie in one straight piece contiguous on the median line. Just beyond the base of the femur the segment bends cephalad upon itself and lies parallel with the coxæ and trochanters (*h*) the tip of the femur lying laterad of the labial lobes and just caudad of the maxillæ. At this point the tibiæ

(i) bend obliquely back across the body so that their tips are not distant from the middle line of the body; the legs touch the pair of the opposite side at the basal fourth of the metatarsus, the remaining tarsal segments running directly caudad and on either side of the middle line of the body. *Middle legs*—The coxæ and trochanters (j) occupy the sternal region of the pupa immediately behind the bend in the fore femur, the tip of the middle trochanter (j) corresponding closely to the tip of the fore tibiæ (i). The middle femur lies beneath (dorsad of) the fore tibia, the middle tibiæ being outside (laterad) of the fore tibiæ and lying parallel with them; the tip of the tibia is about opposite the basal third of the fore metatarsus; the tarsi run parallel with the hind tarsi and end on a level with them. *Hind legs*—Only the coxæ are visible, lying between the bases of the fore metatarsi; the remainder of the leg with the exception of the terminal tarsal segments is concealed by the sheaths of the fore and middle legs and the wings. The femur and tibia are very strongly bent, the tip of the tibia occupying a position that is exactly caudad of the tip of the femur, the tarsi running caudad. The tip of the metatarsus is seen just proximad of the radial region of the wing or just laterad of the antennæ. The hind tarsus projects conspicuously beyond the other tarsi, the tips of the two anterior pairs ending about opposite the middle of the fifth tarsal segment, which here bends strongly inward; tip of the tarsus ending before the caudal margin of the third abdominal segment.

First abdominal segment short, exceeded by the halteres; segments II to VII about equal in length, VIII very narrow, bearing the ninth segment on its caudal face. *Tergites*—First narrow, its caudal margin gently concave, not provided with spicules; segment II indistinctly divided into two approximately equal parts by a transverse false constriction, the caudal margin of the segment provided with about thirty-two chitinized spicules. Segments III to VII with the caudal half of a different texture from the basal half, being somewhat more chitinized, the basal half provided with feeble transverse wrinkles, the caudal margin of each segment provided with chitinized spicules which de-

crease in number toward the end of the body, there being about thirty-two on segment III and twenty-four on segments V and VI. Segment VII has the median line devoid of spicules, each side being provided with about seven arranged in a slightly curved line. Segment VIII very small, inconspicuous, the lateral angles of the caudal margin provided with a few weak hairs and the dorsal surface with several tubercles. Ninth segment bearing the hypopygium, the tergal plate small, ending in two chitinized cylindrical lobes, sharp-pointed, the points directed sharply dorsad. *Sternites*—Segments I and II pale, unarmed, hidden by the leg-sheaths; segments III to VII quite as in the tergites, the third segment with an interrupted row of spicules, about twelve in the middle and two larger ones on either side; in some specimens the row is complete and contains thirty to thirty-two spicules. Segments IV to V with complete rows of about twenty-four spicules; segment VI with a wavy, somewhat broken row of about twenty spicules; segment VII with about five feeble spicules on either side of the bare middle line; ninth sternite broader at base than at tip; tip truncate with the outer angles rounded with a very deep median split. *Pleurites*, non-chitinized, segments II to VII bearing spiracles, these spiracles located just caudad of the false transverse constriction and a little nearer to the sternites than the tergites.

Young pupæ, when alive, are very pale, the soft abdomen being almost white, the chitinized anterior portion very pale brown. Older pupæ are much darker, the chitinized parts becoming black with a bronzy reflexion, the abdomen much paler, of a dirty brownish-grey. The breathing horns are dark brown on the apical half. Young pupæ, in alcohol, are light yellowish brown, abdomen clear yellow, the pleurites a little darker.

Length, from crest to tip of abdomen—♂, 13.2-15.2 mm; ♀, 14-15.4 mm.

Dextro-sinistral width at wing-pad—♂, 2.1-2.2 mm.; ♀, 1.8-1.9 mm.

Dorso-ventral depth at wing-pad—♂, 2.1-2.3 mm.; ♀, 2.2 mm.

## PUPA, ♀

In this sex the crest is smaller (plate III, B), reduced to two triangular lobes with the notch between these lobes very deep; the antennal sheaths are not swollen basally so that the pronotal breathing horns are visible from beneath; antennæ short, extending to a point just beyond the base of the wing. Arrangement of the legs about as in ♂; in one specimen the two terminal tarsal segments of the hind legs project beyond the tips of the other feet; the base of the fore femur is not before the first bend but this segment of the leg is just at this bend. The ninth sternite of the abdomen (plate III, F) is triangular, quite pointed at the tip, with a deep median split; ninth tergite with a broad notch, the lobes small, triangular, divergent, not strongly chitinized and directed strongly dorsad. There is only a little difference in the shape of the ends of the abdomen in the ♂ and ♀ pupa of this species.

Both sexes of the pupæ described from numerous specimens, Fall Creek, Ithaca, New York, May 1, 1913.

*ERIOCERA SPINOSA* Osten Sacken

1859 *Arrhenica spinosa* Osten Sacken; Proc. Acad. Nat. Sci. Phil., p. 244.

## LARVA

Fully grown, fully extended, 40-45 mm.; diameter, 4-5 mm.

Color of larva varies from very pale whitish to rather dark brown; the skin has conspicuous bronzy reflexions in life.

The larval head differs from that of *E. longicornis* Walker, as described before, in the following essentials. (See plate I, A).

*Genal plates* not ending in a sharp protuberance on their inner cephalic angle, the inner margin being almost straight. The lateral lobes of the frontal sclerite are very pronounced, longer than the labrum itself. The hairs at the tip of the antennæ are shorter, not more than one-third to one-fourth the length of the segment. The mandibles (plate I, F) lack the prominent conical tooth at midlength. The head-capsule is much broader in proportion to its length, measuring 3.5 to 3.8 mm. by 1.8 to 2 mm. (across the genal plates).



*Stigmal field* (plate I, figure I) with the spiracles small, dorsal, rounded or rounded-oval, widely separated; four slender, elongate lobes around the stigmal field, one pair being lateral and the other ventral. Lateral lobes with the inner face having a narrow black line, this beginning as an enlarged black spot just ventrad of the spiracle, reaching the tip of the lobe; the dorsal outer edge of this lobe with a dense fringe of long conspicuous reddish hairs, the inner edge of the row beginning just laterad of the spiracle where the hairs are exceedingly short, gradually becoming longer to the tip where they are as long as the lobe itself. Ventral lobe with a narrow black line on the proximal face which divides at the base of the lobe, the ventral branch running along the ventral margin of the stigmal field, the dorsal branch paler, spreading out across the stigmal field and approaching its fellow of the opposite side on the middle line; a dense fringe of conspicuous reddish hairs on the tip of the lobe and continued on the outer dorsal side for a short distance toward the base. A few dusky brown spots on the stigmal field between the stigmata; two small hairs occupying the space between the stigmata. Underneath the caudal lobes and behind the swollen penultimate segment are the four caudal gills, short, stout, cylindrical, unbranched, the lateral pair directed outward, the inner pair directed caudad.

Described from abundant larvæ from along Fall Creek, Ithaca, New York, above the second bridge, in Forest Home, May 1, 1913.

PUPA, ♂

*Antennal sheaths* elongated (plate II, figure E, plate III, figure D), the tip of the sheath lying just before the end of the middle metatarsus, in a few specimens even reaching beyond the tip. *Cephalic crest* (plate II, E, b) very reduced, scarcely projecting beyond the front level of the antennæ; viewed from beneath (plate III, D), it is somewhat quadrate, the fore lateral angles produced into small pointed lobes bearing a long hair at the apex; viewed from the side (plate II, E, b) it is seen to be notched, there being a second lobe, subequal to the ventral one in size, immediately behind it, this also bearing a large hair.

Spine on the scape of the antennæ (plate II, E, c; plate III, D) enormous, somewhat curved, directed ventrad. The inner caudal surface of the eye also bears a conspicuous tubercle. The tentorium between the caudal ends of the antennal scapes is produced into a small median tubercle (plate II, E, d). The tubercles on the base of the labrum or end of the clypeus (plate II, E, e) are very large, close together, the tips strongly chitinized.

*Pronotal breathing horns* long, slender (plate II, E, a), broad at the base, tapering to a rather sharp point, the organ arcuated so that the point is bent strongly ventrad. Mesonotal scutellar lobe prominent, rather strongly projecting. Leg-sheaths with the terminal tarsal segments about on a common level and opposite the end of the third abdominal segment. Wing-pad light brown, the venation showing very clearly, the presence of cell  $M_1$  in connection with the elongate antennæ being characteristic of this species alone in Eastern America.

Second abdominal tergite with a conspicuous basal tubercle on either side of the median line. Spicules very strong, almost spinous, about twenty to twenty-two on tergites II to V. Tergites VI and VII destitute of spicules but with four subapical setiferous tubercles. Tergites II to VII with a conspicuous setiferous tubercle on the ventro-cephalic angle of each caudal annulet. Eighth tergite concave on caudal margin (plate II, D) bearing a pair of strong apical tubercles on either side of the median line. *Sternites*—Segment III with two spicules on each outer angle; segments IV to VI with about sixteen spicules (sometimes as many as twenty); segment VII with about ten. Segments IV to VII with a small setiferous tubercle about midlength of the caudal annulet, widely separated. Segment VIII (plate II, C) without soft pleural region, bearing an apical row of strong spines which is broken only on the dorsum and for a small space on the median line of the venter, there being about twenty of these spines on the segment. Ninth sternite (plate II, C, a) rounded, swollen, with a deep median furrow bearing a small lobe on the ventral side at the end of this split. Ninth tergite (plate II, D, a) produced caudad into two strong

conical points with a V-shaped notch between them, these points directed caudad and slightly dorsad, each one a little split near the tip on the outer face and with a prominent lateral tooth at about mid-length.

Pleural region of abdomen rather restricted, longitudinally wrinkled. Spiracles large, elliptical, transverse, placed about mid-length of the segment. About three small setiferous tubercles on each pleuron ventrad and caudad of the spiracle; another setiferous tubercle on the dorso-cephalic angle of each pleuron.

In life, pupæ vary from a very pale yellowish to dark, almost black, the deepest coloration being the head and thorax; the body often with bronzy reflexions.

Length, from crest to tip of abdomen—♂, 26.5-27 mm.; ♀, 25-28.5 mm.

Dextro-sinistral width at wing-pad—♂, 3.4-3.9 mm.; ♀, 3.4-4 mm.

Dorso-ventral depth at wing-pad—♂, 4-4.2 mm.; ♀, 3.5-4 mm.

#### PUPA, ♀

Quite like the ♂, the sheath of the antennæ short, reaching a point just beyond the end of the fore coxæ or some distance beyond the base of the wing. Ninth sternite (plate III, H) elongated, cylindrical, its tip rounded, feebly split underneath. Ninth tergite (plate III, I) very long, pointed, with a deep median split.

Numerous ♂ ♀ pupæ, Fall Creek, Ithaca, New York, May 27, 1913, taken from the gravelly beds along the creek above the second bridge in Forest Home.

#### *ERIOCERA FULTONENSIS* Alexander

1912 *Eriocera fultonensis* Alexander; Psyche, vol. 19, p. 168, 169.

#### LARVA

Fully grown, fully extended, 18-26 mm.; diameter, 2 mm.

Form long and slender. Color pale flesh color, the cephalic segments a little darker, brownish, the enlarged subterminal swelling almost transparent.

The larval head differs from that of *E. longicornis* Walker or *E. spinosa* O. S., as described before, in the following essentials:

*Genal plates* (plate I, D) at their inner cephalic angle evenly rounded, not produced into a prominent lobe. The *labrum* (plate I, B) is much more produced, conical, bearing a little tuft of hairs at the tip and a small, cylindrical, chitinized tubercle on either side of the tip; the lateral lobes are very prominent, cylindrical, densely clothed with long short hairs, the lobes bent prominently inward. *Antennæ* (plate I, C, a) more club-shaped, the distal end being larger than the base; hairs at the apex short. *Mandibles* (plate I, G) with a prominent conical tooth at mid-length, this tooth squarely truncated at apex and bearing a smaller tooth at its side. Size of the head-capsule, 2.7 by 1.2 mm., across the genal plates.

*Stigmal field* (plate I, J) with the spiracles rounded-oval to rounded, placed obliquely, very widely separated from one another. Four conspicuous lobes surrounding the stigmal field, of which one pair are lateral and the other ventral. Each lateral lobe slender, with a narrow straight black mark on its inner face, at its inner end, this mark scarcely if at all enlarged; the lobe bears a dense fringe of long, delicate, pale brown hairs along its dorsal face, these hairs quite inconspicuous due to their pale color. Each ventral lobe very long and slender, the inner face with a narrow, straight black line which is expanded out at the base into a dark brown triangular mark which meets its fellow of the opposite side on the median line, the two enclosing a pale, oval area between them; a fringe of rather long pale hairs on the apical third of this lobe. A pale brown mark runs from each stigma dorsad. Stigmal field almost destitute of dark spots or marks.

Described from several larvæ taken in sandy banks of Fall Creek, Ithaca, New York, May 30, 1913.

#### PUPA, ♂

The male pupa is quite like the ♀ described below; the bristles on the lobes of the crest are very long, exceeding the

lobe itself, there being three of these elongated bristles on the dorsal lobe and one on the ventral lobe, it being directed caudad. In the  $\delta$  the abdomen ends in a blunt, rounded lobe deeply divided into two parts, strongly suggestive of the powerful hypopygium of the adult male of this species. Total length of the  $\delta$  pupa, 10-12 mm.

PUPA, ♀

Differs from the pupa of the same sex of *E. longicornis* (q. v.) in the following essentials:

The general form is much stouter and the body is covered with numerous appressed hairs. The sharp spine on the scape of the antennæ is lacking; the lobes of the cephalic crest are small (see plate II, F, b; plate III, C) and tend to converge when viewed from beneath, and are covered with small, rounded warts or tubercles; in front, above the base of the antennæ, are two more large lobes so that the crest is four-lobed instead of bi-lobed as in *longicornis*; these anterior lobes are smaller, rounded, and usually end in an apical tip or spur directed ventrad. The pronotal breathing horns (plate II, F, a) are very long and rather slender; the mesonotum more convex than in *longicornis*; the wing-pad usually shows the venation clearly on the pale background and the presence of crossvein *r* connecting  $R_1$  with  $R_2+3$  is distinctive of this species; the absence of cell  $M_1$  separates this pupa from *E. brachycera* O. S., *spinosa* O. S., et al. The leg-sheaths end almost on a level, the outer or hind pair being but a trifle longer than the two inner pair. The spicules on the caudal margin of the abdominal segments are smaller and more numerous, on some of the segments (fifth and sixth tergites) averaging forty. The ninth abdominal segment (plate III, G) is much longer than in *longicornis*, the ninth tergite elongate, pointed, much longer than the ninth sternite and scarcely directed dorsad, being much more like a typical ovipositor than in *longicornis*.

Fully colored pupæ are dark brown, the cephalic crest being paler, the pronotal breathing horn is pale yellow, darkening into brown at the tip. The wing-pads are light yellow with the

venation showing clearly, dark brown. The pleurites of the abdomen are darker brown than the sternites or tergites; ninth segment dull yellow.

Length, from crest to tip of abdomen—♀, 14-16 mm.

Dextro-sinistral width at wing-pad—♀, 1.8-2 mm.

Dorso-ventral depth at wing-pad—♀, 2.5-2.7 mm.

These specimens were taken at Ithaca, New York, as larvæ on May 30, 1913; they were removed from the breeding jars as fully-colored pupæ on June 6, 1913. The single ♂ I possess is represented only by a cast skin, taken as a larva on May 30, and emerging as an adult fly on June 6.

## EXPLANATION OF PLATES

## PLATE I.

- A. Head-capsule of larva of *Eriocera spinosa* O. S., dorsal aspect, a little elongated to show the shape of the head of *fultonensis* and *longicornis*. a, mandible; b, antenna; c, maxilla; d, labrum; e, genal plate.
- B. Clypeo-labral sclerite of *E. fultonensis* Alex., dorsal aspect.
- C. Antennæ of larvæ. a, *E. fultonensis*; b, *E. longicornis*.
- D. Genal plate of *E. fultonensis*, dorsal aspect.
- E. Same of *E. longicornis*.
- F. Mandible of larva of *E. spinosa*.
- G. Same of *E. fultonensis*.
- H. Same of *E. longicornis*.
- I. Dorso-caudal aspect of end of the abdomen of *E. spinosa* larva.
- J. Same of *E. fultonensis*.
- K. Same of *E. longicornis*.
- L. The stigmal field of the last-named, more enlarged.

## PLATE II.

- A. Ventral aspect of ♂ pupa of *E. longicornis*. a, cephalic crest; b, scape of antenna; c, anterior arms of the tentorium; d, maxilla; e, labrum; f, labium; g, fore coxa; h, fore femur; i, fore tibia; j, middle coxæ; k, wing-pad; l, elongate antennal sheath; m, second abdominal segment, bearing spiracle.
- B. Dorsal aspect of ♂ pupa of *E. longicornis*. a, cephalic crest; b, enlarged base of antennæ; c, pronotal breathing horns; d, mesonotal præscutum; e, mesonotal scutum; f, mesonotal postnotum.
- C. Ventral aspect of end of abdomen of ♂ pupa of *E. spinosa*. a, ninth sternite; b, ninth tergite.
- D. Dorsal aspect of same. a, ninth tergite; b, ninth sternite.
- E. Lateral aspect of ♀ pupa of *E. spinosa*. a, pronotal breathing horn; b, cephalic crest; c, spine on antennal scape; d, tubercle on tentorium; e, tubercle on clypeus.
- F. Same of *E. fultonensis*.
- G. Same of *E. longicornis*.

## PLATE III.

- A. Lateral aspect of ♂ pupa of *E. longicornis*.
- B. Ventral aspect of ♀ pupa of *E. longicornis*.
- C. Same of *E. fultonensis*.
- D. Same of *E. spinosa*.
- E. Ventral aspect of head of ♂ pupa of *E. longicornis*.
- F. Lateral aspect of abdomen of ♀ pupa of *E. longicornis*.
- G. Same of *E. fultonensis*.
- H. Ventral aspect of abdomen of ♀ pupa of *E. spinosa*.
- I. Dorsal aspect of the same.